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FUNGICIDES

AND THEIR USE IN PREVENTING DISEASES OF FRUITS.

BY

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U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., February 6, 1905.

Sir: I have the honor to transmit herewith the manuscript for a Farmers' Bulletin entitled "Fungicides and Their Use in Preventing Diseases of Fruits." The bulletin was prepared by Mr. M. B. Waite, pathologist in charge of investigations of diseases of orchard fruits, in the Office of Vegetable Pathological and Physiological Investigations, under the direction of Mr. A. F. Woods, Pathologist and Physiologist.

This bulletin is to supersede Farmers' Bulletin No. 38, "Spraying for Fruit Diseases," published in 1896, and includes a brief description of the most important fungicides and their use in preventing some of the more prevalent fruit diseases.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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FUNGICIDES AND THEIR USE IN PREVENTING DISEASES OF FRUITS.

INTRODUCTION.

The object of this bulletin is to give the principal formulas for fungicides, together with a brief description of their method of preparation, and a summary of the principal diseases of fruits for which satisfactory remedies have been found. Most, though not all, of these remedies consist of spraying. All of the materials can be purchased at most drug stores or from agricultural supply houses. The spray pumps can be obtained from implement dealers or direct from the manufacturers. By consulting agricultural and horticultural papers numerous advertisements of these pumps may be found.

The outline for treatment presupposes a knowledge of the name of the disease and no extended descriptions are given. Unless the reader is familiar with the name and character of the disease he should send a specimen to some plant pathologist for identification. Specimens of diseased fruits or leaves or other portions of plants may be forwarded to any State experiment station or to the United States Department of Agriculture, where a careful microscopical examination will be made and the disease identified.[a] As most of the treatments by spraying are preventive and have to be made some days or often weeks before the disease appears, it is well to make this study of the diseases during the fruiting season, have the specimens examined at that time, and plan for the treatment the coming season.

FUNGICIDES AND THEIR PREPARATION.

COPPER COMPOUNDS.

Formulas for Bordeaux Mixture.

The most valuable fungicide for use in combating plant diseases is Bordeaux mixture, consisting of a mixture of copper sulphate (bluestone) and stone lime slaked in water. The formula varies somewhat

[a] See directions for sending materials for examination and addresses of the various experiment stations at the end of this bulletin (p. 31).

according to the use which is to be made of the spray. Following are the ones most used:

Standard Bordeaux mixture.—The following formula, known as the 6–4–50 formula, the ingredients being mentioned always in the same order, is used in the preparation of the standard Bordeaux mixture:

Copper sulphate (bluestone)	pounds	6
Lime	do	4
Water to make	gallons	50

This mixture can be used successfully on many plants, but on others, like the peach and Japanese plum, it injures the foliage. It also sometimes russets the fruits of apples and pears. It can be increased in strength for certain purposes by reducing the proportion of water, but the formula given above has been regarded as the standard with which all others should be compared, at least in experimental work.

The 5–5–50 formula.—Standard Bordeaux mixture is frequently slightly modified, a very common modification being made according to the formula which follows:

Copper sulphate	pounds	5
Lime	do	5
Water to make	gallons	50

The use of this formula is desirable where the purity of the lime is in doubt, as it makes certain, with lime of any reasonable quality, that all of the copper is properly neutralized. The danger of scorching or russeting the fruit is therefore less. Withholding 1 pound of copper sulphate also cheapens the mixture by a few cents. For these reasons the 5–5–50 formula has come to be quite generally used in orchard spraying. In fact, it has almost replaced the old standard Bordeaux mixture in spraying for the apple scab, bitter-rot, pear and cherry leaf-blight, and similar diseases. In the central Mississippi Valley the 4–5–50 formula has given good results, especially in dry years.[a]

The 4–4–50 and other formulas.—The strength is often still further reduced by using a 4–4–50 formula, but it is questionable whether it pays to reduce the strength. The same result can be secured with sprays having less copper, provided the application is thorough and repeated; but, as in actual experience the cost of applying Bordeaux mixture is often from two to five times the cost of the mixture itself, economy demands the use of the strongest mixture which will do the work without injury to the plants.

For use as a whitewash, a very concentrated mixture, 6–4–20, may be desirable; and for certain diseases Bordeaux mixture can be diluted so as to be equivalent to 6–4–100.

Peach Bordeaux mixture.—The form of Bordeaux mixture most harmless to foliage is made up by the formula 3–9–50, having a considerable

[a] See also Farmers' Bulletin No. 247.

excess of lime. This may be known as "peach Bordeaux mixture," and contains ingredients as follows:

Copper sulphate	pounds..	3
Lime	do....	9
Water to make	gallons..	50

Modified Bordeaux preparations.—Various modifications of the original Bordeaux mixture have been suggested and tried. The principal ones, however, are the "soda Bordeaux mixture" and the "potash Bordeaux mixture." The former consists of 6 pounds of copper sulphate, 2 pounds of caustic soda, and 50 gallons of water. The latter is the same except that an equal quantity of caustic potash is substituted for the soda. Other materials are sometimes added to Bordeaux mixture to increase its spreading power. The most successful is ordinary hard soap, dissolved in hot water and added at the rate of 4 pounds to the barrel, and this modified Bordeaux mixture is known as "soap Bordeaux."

Method of Making Bordeaux Mixture in Small Quantities.

Where only a small quantity of Bordeaux mixture is required—from a bucketful to a barrel—the method described by Dr. B. T. Galloway in Farmers' Bulletin No. 38 gives excellent results. Two half-barrel tubs are made by sawing a barrel through the middle. One tub is used for the bluestone solution and the other for the milk of lime, and each tub should contain 23 to 25 gallons. One man dips the bluestone solution with a bucket and pours it into a barrel or other vessel, and another man simultaneously dips up and pours in bucketfuls of the milk of lime (fig. 1). The lime solution should be kept well stirred. If only a single barrel is to be made, the materials may be dissolved in the dilution tubs, but if a number of lots are required the materials can be kept in stock solution (see p. 9) and simply transferred by dipping. In preparing very small quantities of Bordeaux mixture, buckets or similar vessels may be substituted for the half-barrel tubs. It is possible for a single operator to dip a bucketful of the bluestone

FIG. 1.—Making Bordeaux mixture. The two men pour together the diluted lime milk and the bluestone solution into a barrel or spray tank and stir well.

solution and then a bucketful of milk of lime and pour them together into a vessel. It is usually preferable to have a bucketful or so of water in the receptacle into which the solutions are to be poured, but this is not essential.

The better and quicker way of making up Bordeaux mixture by the barrel consists in placing the two half-barrel tubs on an elevated platform and then, by means of hose or spigots, allowing the two solutions to flow together into a barrel. This method is more fully described farther on (p. 9).

Straining the materials.—No matter what quantity of mixture is to be made up, it is necessary to strain the materials through a wire strainer. The best type of strainer is made of brass wire, with 18 or 20 meshes to the inch. If all the copper solution is strained and then the milk of lime is strained into the dilution vessels, it will not be necessary to strain the Bordeaux mixture as, on account of its flocculent character, it is sometimes more difficult to pass through the strainer than the lime milk. Some very good strainers made of copper are on the market and may be obtained from the makers of spray pumps. One of the best, which can be made at home, is in the form of a box about a foot square (fig. 2), the bottom of which is a rather heavy board (preferably of hard wood) with a hole bored through it, into which a piece of gas pipe 1½ to 2 inches in diameter and 8 to 12 inches long is fitted. The box is of course open at the top. Fitting just inside this box is a second and lighter box, also open at the top, and having an overhanging strip nailed around the top which supports it. The bottom of this inner box should be made so as to slope at an angle of about 30°, and should be made of wire screen. The slanting bottom makes it harder to clog with the spray, and the inner box, being movable, can be inverted and washed in a tub of water.

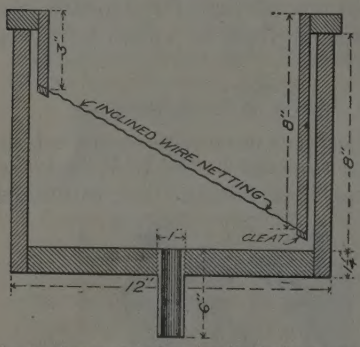

FIG. 2.—Cross section of strainer for Bordeaux mixture. The inner frame with inclined wire strainer fits loosely into the outer box. A short 2-inch iron pipe conducts the liquid into the spray-tank. (After Alwood and Phillips, Virginia Experiment Station.)

Method of Preparing Bordeaux Mixture for Large Operations.

In large operations stock solutions should always be used, as the time required to dissolve the material is saved.

Stock solutions.—These can be prepared of both the copper sulphate and the lime. They may be made by dissolving copper sulphate in water at the rate of 1 pound per gallon, and lime in the same ratio, although a strength twice as great may be used in warm weather. When stock solutions are on hand it is only necessary to measure off the required quantity of each and dilute with water before mixing. In preparing a stock solution of copper sulphate, a 50-gallon barrel may be filled about two-thirds or three-fourths full of water; then a sack, or a box with perforations over which copper wire has been tacked, containing 50 pounds of bluestone, should be suspended in the upper part of the barrel and enough water added to fill the barrel. In from twenty-four to thirty-six hours this material will be entirely in solution, and the sack or box may be removed. A slight stirring will insure the even distribution of the bluestone, after which the solution is ready for use.

The copper sulphate should be measured in a copper or granite-ware receptacle, iron or tin vessels being quickly destroyed by either copper sulphate or Bordeaux mixture.

Use of an elevated platform.—If possible the dilution tanks should be raised so high on an elevated platform that the mixture can be conducted by gravity directly into the spray tank beneath (fig. 3). If a hillside is available, it is much the most convenient place to do the work. The platform can be arranged with a roadway on its upper side so that the lime and bluestone can be delivered there, while the spray tank is filled from the lower side.

FIG. 3.—Elevated plant for making Bordeaux mixture on a large scale. The water supply is merely indicated. In the absence of a water supply in pipes a water tank will be needed. The materials flow by gravity directly into the spraying tank, which thus serves as the mixing tank. A mixing tank for storage directly under the spigots will increase the capacity of the outfit, but usually will not be necessary.

The water supply.—A water supply of some sort is necessary; a tank filled by a windmill pump and elevated so as to be a few feet above the dilution tanks is a great advantage. Hose may be used to fill the dilution tanks, or an iron pipe with a spigot may be placed over each tank. Each dilution tank should hold half the quantity it is desired to make up at one time—that is, if a 200-gallon spray tank is to be filled the dilution tanks must hold about 100 gallons each. There is

no objection to adding a few extra gallons of water, but it is better to have the tanks hold just the right quantity.

Methods of mixing the solutions.—Either of two methods of mixing can be employed: One in which the spray material is conducted directly from the dilution tanks into the spray tank and actually mixed in this tank; the other in which a mixing tank sits just below the dilution tanks and from which the spray, after being mixed up, is conducted by gravity into the spray tank. In certain ways the latter is more convenient than mixing directly into the tank, but unless the operations are somewhat extensive it will hardly justify the extra expense. In very large operations, however, a separate mixing tank is recommended—or perhaps even two of them side by side—so that batches of the mixture can be kept on hand for a few moments awaiting the spray wagons.

Testing Bordeaux Mixture.

When Bordeaux mixture is properly prepared it is of a brilliant sky-blue color. If the lime is air-slaked or otherwise inferior in quality, resulting in a bad mixture, the preparation will have a greenish cast, and if this is very pronounced, the mixture will injure the foliage.

In order to make certain that the copper sulphate is properly neutralized by the lime, the yellow prussiate of potash test may be used. A small bottle containing a 10 per cent solution of yellow prussiate of potash can be secured from a druggist. After stirring the Bordeaux mixture, a drop of this solution is allowed to fall on the surface of the preparation. If free copper is present, the drop will immediately turn reddish-brown in color. Lime should then be added until the brown color fails to appear. If the reaction is complete, the yellow prussiate of potash solution will remain a clear yellow until it disappears in the mixture.

Adding Insecticides.

One advantage of Bordeaux mixture is the possibility of adding arsenical insecticides to the preparation and thus of spraying at the same time for diseases and for the codling moth and leaf-eating insects. Paris green, at the rate of one-quarter pound to 50 gallons of Bordeaux mixture, may be considered as the standard formula for this purpose. London purple, arsenate of lead, and other arsenicals may be used in the same way. Bordeaux mixture may be considered as so much water in the formulas for this class of insecticides. As a matter of fact, the slight excess of lime in the standard mixture renders it an especially suitable medium for distributing these insecticides.

Dust Bordeaux Mixture.

Formula.—The formula given by Mr. W. M. Scott, of this Bureau, for dust Bordeaux mixture and the method of preparation are as follows:

4 pounds of copper sulphate in 4 gallons of water.
4 pounds of lime in 4 gallons of water.
60 pounds of slaked lime dust.

Dissolve the 4 pounds of copper sulphate in 4 gallons of water and slake 4 pounds of lime in 4 gallons of water. When cool pour the two solutions together simultaneously into a tub. Allow the resulting precipitate to settle, decant off the liquid, pour the wet mass of material into a double flour bag, and squeeze out as much water as possible. Then spread out the dough-like mass in the sun to dry. After a day's drying it can easily be crumbled into an impalpable powder by crushing with a block of wood or even with the hand. This powder should be screened through a sieve of brass wire having at least 80 meshes to the inch and should then be thoroughly mixed with 60 pounds of slaked lime dust.

The lime dust is best prepared by slowly sprinkling a small quantity of water over a heap of quicklime, using barely enough water to

FIG. 4.—Applying the dust spray in a peach orchard.

cause the lime to crumble into a dust. The heat generated will soon drive off the excess of moisture, and the dust should then be passed through a screen of 80 meshes to the inch. This powder is usually applied by means of a blower, as illustrated in figure 4.

If desired, 4 pounds of sulphur and 1 pound of Paris green may be added to each 60 pounds of Bordeaux mixture dust.

Finely powdered copper sulphate, used with lime as a conveyer, is also sometimes applied to plants. When so employed at least 15

pounds of slaked lime dust should be used to each pound of copper sulphate, as this will make a pretty strong fungicide.

The manufacturers of dust sprayers have on the market several ready-made preparations. As a rule, these do not contain as much copper sulphate as is recommended in the above formula.

Value of dust sprays.—The expense of handling large quantities of water in making up the liquid Bordeaux mixture has deterred many orchardists from using it. In case of certain mountain orchards, it is not practicable to haul the water up the steep hills or mountain sides, nor is it feasible to drive between the tree rows with heavy spraying tanks. There is a very urgent demand, therefore, for successful dry fungicides to be applied without the use of water, as the weight of the material handled is very much reduced. So far, however, in the treatment of apple scab, bitter-rot of the apple, pear leaf-blight, black-rot of the grape, and other fungous diseases requiring careful spraying, the dust method may be regarded as still in the experimental stage and of doubtful value. It is not to be compared with properly made Bordeaux mixture applied as a spray in the treatment of these diseases. In the treatment of the codling moth, however, better success has been obtained, and some help may be expected against fungi. Mr. Scott's formula is the result of considerable experimenting, and it is recommended as the best one to use. The writer is not able, however, to recommend dust spraying for general use, and wherever liquid spraying is practicable it should by all means be used.

Formulas for Other Copper Solutions.

Copper sulphate solution.—The formula for copper sulphate solution is as follows:

Copper sulphate (bluestone)	pounds	3
Water	gallons	50

Dissolve the bluestone in the water in the same manner as for the preparation of Bordeaux mixture (p. 9). A more dilute solution (2 pounds to 50 gallons) is sometimes used on foliage.

Caution.—This solution is severely injurious to plants in foliage, and should therefore be applied only during the dormant period. Even the more dilute solution is usually injurious to leaves and flowers.

Copper acetate solution.—The following formula is used for copper acetate solution:

Dibasic acetate of copper	ounces	6
Water	gallons	50

Copper acetate is readily soluble in water, and the solution may be effected by simply adding the salt to the water and stirring thoroughly. Its use is much the same as that of ammoniacal copper carbonate, and

it is recommended for application to ripening fruit when it is desired to avoid the staining effect of Bordeaux mixture, though it is much inferior to the latter as a fungicide.

Caution.—The injurious effect of acetate of copper on foliage is somewhat greater than that of Bordeaux mixture, and to such susceptible foliage as that of the peach it should be applied sparingly, if at all.

Ammoniacal copper carbonate.—The formula for ammoniacal copper carbonate is as follows:

Copper carbonate	ounces..	5
Strong ammonia (26° Baumé)	pints..	2 to 3
Water to make	gallons..	50

Dilute the ammonia with about 2 gallons of water, as it has been found (Penny, Del. Exp. Sta. Bul. 22) that ammonia diluted seven or eight times is a greater solvent for copper carbonate than the concentrated liquid. Add water to the carbonate to make a thin paste, pour on about half of the diluted ammonia, and stir vigorously for several minutes; allow it to settle and pour off the solution, leaving the undissolved salt behind. Repeat this operation, using small portions of the remaining ammonia water until all the carbonate is dissolved, being careful to use no more ammonia than is necessary to complete the solution. Then, after adding the remainder of the required quantity of water, the solution is ready for application.

Ammoniacal copper carbonate is a clear, light-blue solution, which upon drying leaves little or no stain. As a fungicide it is inferior to Bordeaux mixture, and should be used only as a substitute for the latter when the stain of Bordeaux mixture upon ornamental plants and maturing fruits is objectionable.

Caution.—Plants likely to be injured by Bordeaux mixture are susceptible to more severe injury from applications of ammoniacal copper carbonate. This solution should therefore be applied to such plants with caution, if at all.

Eau celeste (modified).—The following formula is used for a solution of eau celeste:

Copper sulphate	pounds..	4
Ammonia	pints..	3
Sal soda	pounds..	5
Water to make	gallons..	45

Dissolve the copper sulphate in 10 or 12 gallons of water, add the ammonia, and dilute to 45 gallons; then add the sal soda and stir until dissolved. Eau celeste is an effective dormant spray for the peach leaf-curl and other similar diseases, but it is unsafe to use on the foliage of most plants.

Caution.—This wash should not be used on the foliage of stone fruits, and should be applied to other growing plants only with due caution.

SULPHUR AND OTHER FUNGICIDES.

Lime-Sulphur-Salt Wash.

The fungicide called lime-sulphur-salt wash is made up as follows:

Lime, unslaked	pounds..	20
Sulphur (flour or flowers)	do....	15
Salt	do....	10
Water to make	gallons..	50

Many different formulas are used in making up this wash, all apparently good and giving almost the same result when not too dilute. The above formula seems to be the best, and has been extensively used. If the lime is high-grade stone lime, 15 pounds will be sufficient to dissolve all the sulphur. With average lime 20 pounds is the better quantity, but with poor or partly air-slaked lime 25 to 30 pounds are necessary. Lime absorbs an equal weight of water in becoming air-slaked. The writer has used partly air-slaked lime with good results, but in weighing out the lime the water in air-slaked lime must be taken into account and a larger quantity used.

Preparation in small quantities.—Place about 10 gallons of water in an iron kettle over a fire, make the sulphur into a paste with a little water, and when the boiling point is nearly reached add the fresh lime and the sulphur together. The mixture should be constantly stirred and the boiling continued for forty to sixty minutes. The object of the cooking is to dissolve the sulphur, and when this is accomplished further boiling is useless but not harmful.

The salt may be added at any time during the process of boiling or entirely omitted. It is generally conceded, however, that salt increases the adhesiveness of the wash as it does ordinary lime whitewash, and for this reason it is perhaps advisable to use it, although it is not supposed to strengthen the fungicidal property of the mixture. Possibly, also, the salt hastens the solution of the sulphur by raising the boiling point or by its solvent action.

It has been found that the sulphur dissolves more readily in a concentrated mixture with lime, and the quantity of water used during the process of boiling should, therefore, be reduced to a minimum. The mixture should not be allowed to become pasty, however, and water, preferably hot, should gradually be added till the barrel is nearly full when finished. When the cooking is completed pass the mixture through an iron wire strainer (not brass or copper) and dilute with the required amount of water.

The wash may be applied either hot or cold with practically the same results, though the warm mixture is less likely to clog the nozzles. If allowed to stand over night, sulphur crystals will form on

the bottom and sides of the containing vessel, necessitating reheating or straining before application. It is difficult to dissolve the lime-sulphur crystals after they have once formed. For this reason it is better not to prepare more than can be used the same day.

Preparation in large quantities.—The lime-sulphur-salt wash requires so much work in boiling and mixing that it affords an opportunity for ingenious arrangements of outfits and plants. Where only a few barrels of the mixture are to be made—say for not more than a few hundred trees—boiling in a kettle, or hog-scalder, or feed-cooker, will answer very well. In fact, quite extensive spraying operations are carried on in California by the use of a battery of iron kettles set in brick furnaces and fired with prunings and dead wood from the orchards.

The most economical and convenient way is to prepare a steam plant with tanks or barrels for boiling the spray by steam. Several differ-

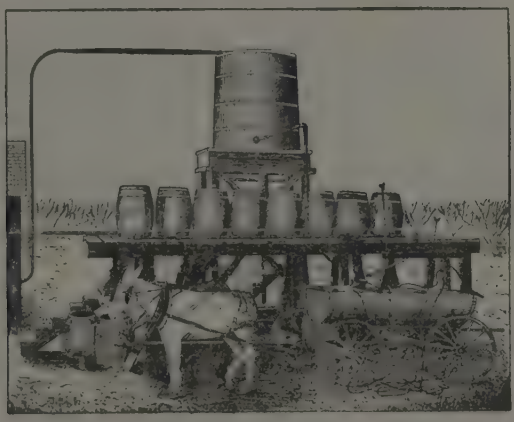

FIG. 5.—Side view of plant for making lime-sulphur-salt wash, modified from one built by Mr. John T. West, Thomson, Ga. The engine house is partly out of view at the left. In this a boiler and pump are located. The large tank is for the water supply. The elevated platform enables the material to flow by gravity into the spraying outfit. An improvement for northern climates is to cover the whole outfit, including boiler, under one building.

ent forms are in use (figs. 5 and 6). Some of the first very successful steam plants consisted of elevated wooden tanks, with pipes running around inside at the bottom for conducting the steam. The outfit especially recommended by the writer, however, involves the use of steam pipes by which steam is conducted into the barrel and liberated among the contents.

A 50-gallon barrel makes a very convenient unit for even the most extensive operations. Mr. J. H. Hale, of Connecticut and Georgia, has three of these outfits in use; two with 10 barrels each, and one in Georgia of 20 barrels capacity. The steam pipe from the boiler should be of the same size as the outlet of the boiler. The two

branches should be somewhat smaller in size, but should have the same total capacity. The vertical pipes should be three-fourths of an inch

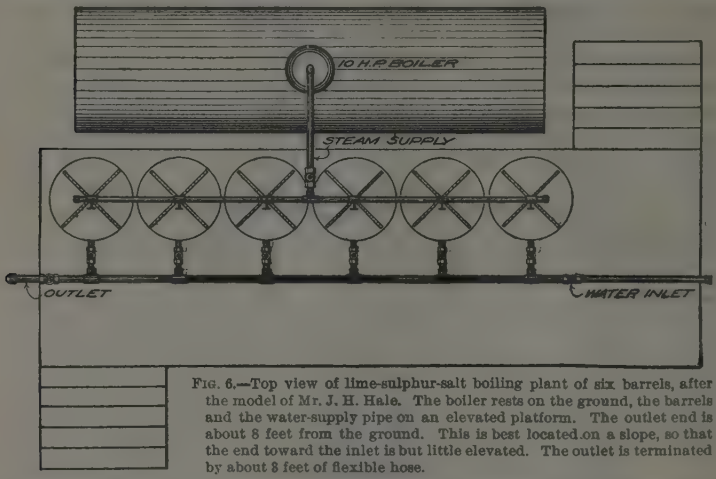

FIG. 6.—Top view of lime-sulphur-salt boiling plant of six barrels, after the model of Mr. J. H. Hale. The boiler rests on the ground, the barrels and the water-supply pipe on an elevated platform. The outlet end is about 8 feet from the ground. This is best located on a slope, so that the end toward the inlet is but little elevated. The outlet is terminated by about 8 feet of flexible hose.

or slightly less. The perforations may be one-eighth of an inch or even as small as one-sixteenth of an inch in size. Steam is conducted

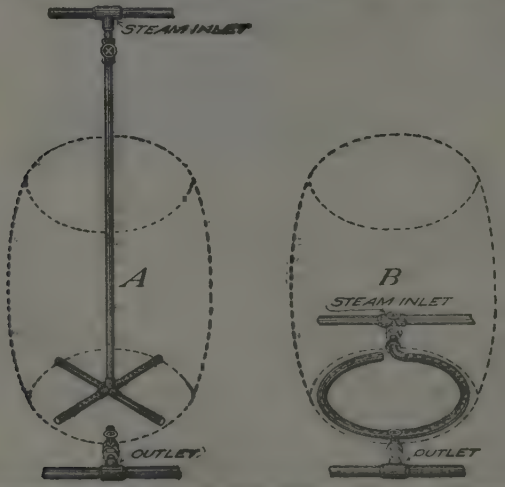

FIG. 7.—Two styles of perforated outlet pipes for conducting steam into barrels: *A* entering from above and terminating in a double T with perforations on the arms; *B* entering through the barrel near the bottom and forming a circle.

directly into the liquid, escaping through the perforations (fig. 7). The water-supply pipe extends on to the platform alongside the bar-

rels, having a branch running into each barrel. This pipe should be about 1½ to 2 inches in diameter, and the arrangement of the valves should be such that fresh water can be turned into the outlet pipe, which extends over the end of the platform and turns downward a foot or so. It has 3 or 4 feet of hose to lead the liquid into the tank, which is driven underneath.

In making lime-sulphur-salt spray the residues should be carefully watched. If yellow sulphur remains in the barrel, more lime is needed in the mixture. If a residue of both lime and sulphur remains, longer boiling should be given. Only the sand and bits of rock or other impurities in the lime should remain.

Sulphur and Resin Solution.

The mixture known as sulphur and resin (sar) solution is made up as follows:

Sulphur (flowers or flour)	pounds	16
Resin (finely powdered)	do	½
Caustic soda (powdered)	do	10
Water to make	gallons	6

Place the sulphur and resin, thoroughly mixed, in a barrel or smaller vessel and make a thick paste by the addition of about 3 quarts of water. Then stir in the caustic soda. After several minutes the mass will boil violently, turning a reddish brown, and should be stirred thoroughly.

After boiling has ceased add about 2 gallons of water and pour off the liquid into another vessel and add to it sufficient water to make 6 gallons. This form of stock solution may be used at the rate of 1 gallon to 50 of water for spraying most plants and for soaking seeds.

Potassium Sulphid.

For a fungicide of potassium sulphid the following formula may be used:

Potassium sulphid (liver of sulphur)	ounce	1
Water	gallons	3

Dissolve the liver of sulphur in the required amount of water and use immediately. On standing the mixture deteriorates rapidly. It is effective for surface mildews, such as gooseberry mildew.

Sulphur.

Sulphur is used as a fungicide in a pure state. It is on the market in a number of different commercial grades. The "flowers" of sulphur is the lightest and usually the purest chemically. The "flour" of sulphur, while finely divided, is not so light. It is sold in different

degrees of fineness and purity. Stick sulphur is the same material in a solid stick.

Flowers of sulphur dusted on plants is useful as a remedy for mildew, especially the rose mildew and the powdery grape mildew.

The heating pipes of greenhouses are frequently painted with flour of sulphur made into a paste with water for the production of fumes, which act to prevent various diseases. Fumes from burning sulphur may be used to disinfect empty greenhouses, storage houses, and outbuildings.

Caution.—Fumes from burning sulphur are destructive to plant life and should never be used to disinfect inclosures containing live plants or fresh fruits and vegetables, as they will kill them wholly or in spots.

Corrosive Sublimate.

Corrosive sublimate (mercuric chlorid) is used at the rate of 1 part to 1,000 parts of water to disinfect the knife or other tools used in cutting out pear-blight. Convenient-sized tablets of this substance can be purchased at a drug store and kept in a bottle. One of these tablets may be added to a bottle containing the required quantity of water (usually a pint), and a sponge or cloth saturated with this solution may be used to wipe the tool after each cut. It is also advisable to disinfect in this way the wound made by the removal of the blighted wood.

Caution.—Taken internally, corrosive sublimate is a deadly poison and should be handled as such.

THE TREATMENT OF SOME IMPORTANT DISEASES.[a]

APPLE DISEASES.

Scab (*Venturia inaequalis*).—Spray with Bordeaux mixture (either the 4–5–50 or the 5–5–50 formula), as follows: First, when the cluster buds have opened and exposed the flower buds; second, just after the petals have fallen; third, a week or ten days later; and, fourth, two weeks after the third spraying. In a rainy season this disease is rather difficult to control and may require five or six applications. In case of a dry spring, however, only three applications are usually required.

Bitter-rot (*Glomerella rufomaculans*).—Beginning thirty to forty days after the fruit is set, spray thoroughly with Bordeaux mixture at intervals of two weeks until five or six applications have been made. This treatment should be in addition to any previous applications that

[a] For a fuller discussion of the nature and treatment of the diseases mentioned under this heading, see the publications of the State Agricultural Experiment Stations and the U. S. Department of Agriculture.

may have been made for scab, but in case treatment for the latter disease has been omitted the first application for bitter-rot should be made not later than thirty days after the fruit is set. Recent experiments conducted by Mr. W. M. Scott, of this Bureau, show that the bitter-rot may be thoroughly controlled by the treatment outlined.[a]

So far as practicable, gather up and burn during the autumn and winter all of the rotten or mummified fruit; also cut out and burn all the limb cankers. These precautions are particularly desirable where a thorough course of spraying has not been properly carried out.

Black-rot (*Sphaeropsis malorum*).—The treatment for black-rot is the same as that for apple scab.

Pear-blight, Fire-blight, or Twig-blight.—The treatment is the same as that given below for this disease of the pear.

Leaf-blights (*Phyllosticta* spp. and *Sphaeropsis malorum*).—Two or three applications of Bordeaux mixture at intervals of ten days to two weeks, beginning when the trees are just in full foliage, will ordinarily prevent these diseases. The treatment for apple scab or bitter-rot will prevent these diseases also.

Flyspeck (*Leptothyrium pomi*).—Bordeaux mixture thoroughly applied about the time the fruit is one-fourth grown and repeated two weeks later may be expected to prevent this trouble very effectually.

Canker (*Glomerella rufomaculans*, *Sphaeropsis malorum*, and *Nectria* spp.).—Remove affected branches so far as practicable, cut out or scrape the remaining cankers, and paint the wounds with white lead.

Powdery mildew (*Sphaerotheca mali*).—This disease is preventable by spraying with ammoniacal solution of copper carbonate. On nursery seedlings four to six applications may be necessary at intervals of ten days to two weeks, beginning as soon as the foliage is out.

Rust (*Gymnosporangium* spp.).—Spray with Bordeaux mixture as soon as the blossoms have fallen and again a week or ten days later. These are the same applications as the second and third treatments for apple scab. The disease is only partly preventable by this treatment. This fungus has its alternate generation on the red cedar, producing the so-called cedar apples. Removal of the red cedars in the neighborhood of the orchards has been recommended.

PEAR DISEASES.

Blight (*Bacillus amylovorus*).—Cut out at all seasons, but especially cut out hold-over blight in late autumn and again in spring before the blossoms open. In cutting blight, disinfect knives and tools as well as cut surfaces with corrosive sublimate solution (1 to 1,000). Prune the

[a] For details of these experiments, see Bulletin No. 93, Bureau of Plant Industry, U. S. Department of Agriculture.

trees so that fruit spurs are borne on fruiting branches rather than on the main limbs. The vase form of growth, with the spurs removed from the main branches, is especially recommended. All framework branches should be repeatedly forked to facilitate future cutting.

Leaf-blight (*Entomosporium maculatum*).—Spray with standard Bordeaux mixture after the trees are in full foliage, one to two weeks after the blossoms have fallen. Follow with second and third treatments at intervals of two weeks. This treatment is very successful.

On pear seedlings and nursery stocks spray as soon as the leaves are out and follow with five or six treatments at intervals of a week or ten days, or until new leaves cease forming.

Canker (*Sphaeropsis malorum*).—Prune out the diseased twigs and branches as far as possible, cut out the cankered spots, and disinfect the wounds. Spray the trees when dormant with Bordeaux mixture until they are coated. A second spraying after the first has dried will be especially effective.

QUINCE DISEASES.

Black-rot (*Sphaeropsis malorum*).—The treatment is the same as for apple scab (see p. 18).

Pear-blight (*Bacillus amylovorus*).—The treatment is the same as for blight of the pear (see p. 19).

Leaf-blight (*Entomosporium maculatum*).—The treatment is the same as for the same disease of the pear (see above).

Rust (*Gymnosporangium* spp.).—The treatment is the same as for rust of the apple (see p. 19).

PEACH DISEASES.

Brown-rot (*Sclerotinia* (*Monilia*) *fructigena*).—Gather and burn all rotten or mummified fruits from the trees and the ground. Prune out all twigs affected. Prune the trees so as to admit as much air and sunlight as possible. Avoid overstimulation with stable manure and nitrogenous fertilizers. Avoid as far as possible planting trees on low, wet, or undrained land. Select sites having well-drained soil and good atmospheric drainage. Spray just before the blossoms open with standard Bordeaux mixture. When the fruits are one-fourth of an inch in diameter spray with 3–9–50 Bordeaux mixture. Make two or three additional sprayings at intervals of ten days to two weeks.

Caution.—Even the weak mixture here advised injures the foliage more or less, sometimes resulting in complete defoliation. Spraying is therefore advised only when conditions are such that the loss of the crop is anticipated. Young growing trees are less injured by the spray because they are continually forming new leaves.

Leaf-curl (*Exoascus deformans*).—Spray when buds are dormant, three of four weeks before the blossoms open, with Bordeaux mix-

ture, copper-sulphate solution, or lime-sulphur-salt solution. Each is effective against the leaf-curl fungus. Copper sulphate is the simplest and cheapest, but Bordeaux mixture persists and is more effective against Monilia and other fungi, and is therefore preferable where these are to be fought; while the lime-sulphur-salt solution is, in addition to its fungicidal action, one of the best known remedies against scale insects.[a]

Scab (*Cladosporium carpophilum*).—Spray as for brown-rot. This treatment will be successful except in extreme cases.

Pustular spot (*Helminthosporium carpophilum*).—Spray as for brown-rot. Probably fewer treatments are necessary for success.

Yellows.—Find every case by inspecting all trees during the ripening of the fruit. Second and third inspections are desirable. Pull up and burn all infected trees as soon as discovered, no matter how slightly affected. This treatment is very successful when thorough, the disease being one of the easiest of all orchard diseases to control, especially when the fight is carried on systematically throughout a community. Complete eradication is difficult.

Rosette.—This disease is controlled with ease by the same treatment as for yellows, except that inspection should be early in the season.

Little-peach.—The treatment is the same as for yellows, but the early symptoms are more difficult to recognize. On this account the disease may be harder to control.

PLUM DISEASES.

Brown-rot (*Sclerotinia fructigena*).—See treatment of the same disease under peach.

Black-knot (*Plowrightia morbosa*).—During the autumn and early winter cut out and burn the knots. Make the cut 4 or 5 inches below the visibly infected portion to insure the removal of all the fungus threads. During the summer watch for and remove the new knots as soon as they appear.

When the disease is very troublesome spray with standard Bordeaux mixture when the buds begin to swell in the spring, and repeat with peach Bordeaux mixture soon after the blooming period.

Leaf-blight (*Cylindrosporium padi*).—Spray with Bordeaux mixture as soon as the blossoms are shed, and repeat two or three times at intervals of two weeks. In the case of the Japanese plum, use the peach Bordeaux mixture.

Yellows.—The treatment is the same as that given above for this disease of the peach.

Rosette.—Treat the same as that given above for peach rosette.

[a] See Bulletin No. 20, Division of Vegetable Physiology and Pathology, U. S. Department of Agriculture.

Little-peach.—Follow the recommendations given under peach (page 21).

CHERRY DISEASES.

Brown-rot (*Sclerotinia fructigena*).—The treatment should be the same as that for the same disease of peach (see page 20).

Black-knot (*Plowrightia morbosa*).—Use the same treatment as that recommended for black-knot of the plum (see page 21).

Leaf-blight (*Cylindrosporium padi*).—Spray with Bordeaux mixture as soon as the foliage is out, and again ten days or two weeks later. In severe cases a third and a fourth application may be necessary. On nursery trees the new leaves must be sprayed as they appear through the season.

Powdery mildew (*Podosphaera oxyacanthae*).—Spray with Bordeaux mixture about two weeks after the leaves are out and repeat two or three times at intervals of ten days. In case of nursery stock about six applications may be necessary.

GRAPE DISEASES.

Black-rot (*Guignardia bidwellii*).—Clean up and burn all dead branches, leaves, and rotten fruit of the previous year in early spring. Spray with Bordeaux mixture when the buds are swelling, so as to cover all the wood posts, trellises, etc., as well as the vines. Ten or twelve days later, when the grapes are in bud, make the second treatment. The third treatment is made when the fruit has set. Repeat the sprayings at intervals of ten days to two weeks until the fruit approaches maturity. To avoid discoloration of the fruit the ammoniacal copper carbonate solution may be substituted for the Bordeaux mixture for the last two sprayings. In an average season six treatments should be sufficient, but in a rainy or unfavorable season eight applications may be required for successful results. In a rainy season or in unfavorable localities, especially in the South, Bordeaux mixture containing less water, namely, the 6–4–25 formula, may be used.

Anthracnose (*Sphaceloma ampelinum*).—The treatment is the same as for black-rot, except that iron sulphate solution is preferred by some for treating the dormant vines.

Downy mildew or brown-rot (*Plasmopara viticola*).—Treat the same as for black-rot, except that the first two or three sprayings may be dispensed with, as this disease does not appear early in the season.

Powdery mildew (*Uncinula necator*).—This disease is usually not serious enough to demand treatment, but, when necessary to spray, use the ammoniacal solution of copper carbonate, giving from three to five treatments at intervals of ten days to two weeks, beginning after the fruit is well set. On the Pacific coast and on vines grown under glass dusting with flowers of sulphur is successful.

STRAWBERRY DISEASE.

Leaf-blight (*Sphaerella fragariae*).—Spray with standard Bordeaux mixture every two weeks during the season, beginning after the crop is harvested. Four to six applications are required.

RASPBERRY DISEASE.

Anthracnose (*Gloeosporium venetum*).—Cut out and burn the badly diseased canes and spray thoroughly with Bordeaux mixture before the leaf buds open. Spray the young canes soon after they appear above ground. Repeat the application ten days or two weeks later, and again just before blooming.

BLACKBERRY DISEASE.

Anthracnose (*Gloeosporium venetum*).—The treatment is the same as for raspberry anthracnose.

CRANBERRY DISEASES.

Blast and scald (*Guignardia vaccinii*).—Spray thoroughly with standard Bordeaux mixture to which 4 pounds of resin-fishoil soap has been added, first, early in June before any of the flowers have opened; second, immediately after the maximum flowering period; third, fourth, and fifth applications at intervals of two weeks. The oil is the most important application in combating the blast. Dead vines and rakings should be burned.

Rot (*Acanthorhynchus vaccinii*).—Follow the same treatment as for cranberry scald.

Anthracnose (*Glomerella vaccinii*).—Follow the same treatment as for cranberry scald.

CURRANT DISEASES.

Leaf-spots (*Septoria ribis* and *Cercospora angulata*).—Spray with Bordeaux mixture about five times at intervals of two weeks, beginning while the buds are swelling.

Powdery mildew (*Sphaerotheca mors-uvae*).—Treat the same as recommended under the same disease on the gooseberry. (See below.)

Anthracnose (*Gloeosporium ribis*).—The treatment is about the same as that given above for leaf-spots.

GOOSEBERRY DISEASES.

Powdery mildew (*Sphaerotheca mors-uvae*).—Spray with potassium sulphid at the rate of 1 ounce to 2 gallons of water. Apply every two weeks during the season, beginning just as the buds are swelling.

Leaf-spots (*Septoria ribis* and *Cercospora angulata*).—Follow the treatment outlined under the same disease of currant.

TYPES OF SPRAY OUTFITS.

SPRAYERS FOR SMALL OPERATIONS.

Bucket pumps.— It is possible to apply small quantities of spray on a few plants, in a small garden, for instance, with a garden syringe. Most of these syringes, however, do not give a sufficiently fine spray to be satisfactory. The old-style syringe was intended to throw too much water to fulfill the requirements of a modern sprayer. It is even possible to test the effect of Bordeaux mixture by switching it on with a small whisk broom or brush. Such expedients, however, are now supplanted by the bucket pump, which meets the requirements of the garden and other small operations. Several different forms are on the market, made by different manufacturers, and some of them are very efficient. In a few cases these pumps are supplied already mounted in a galvanized-iron bucket, but usually the pump is inserted into a wooden bucket containing the spray (fig. 8). To do good work the bucket pump usually requires two operators, notwithstanding the familiar advertisements in agricultural papers showing a single operator. With the bucket pump good pressure can be secured, and if suitable hose and nozzles are used results entirely satisfactory are possible.

FIG. 8.—Hand bucket spray pump. A longer hose than that shown is needed for convenient using.

The knapsack pump.—This form of spray outfit consists of a copper tank which may be strapped to the operator's back like a knapsack. This contains a small pump which may be operated with one hand while the nozzle is held in the other (fig. 9). This style of outfit was used widely in the first experiments with Bordeaux mixture, especially with vine diseases. It is still used in vineyards situated on hillsides where a horse can not go and in thickly planted or low growing crops.

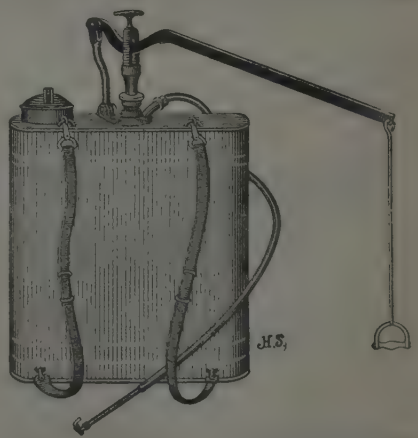

FIG. 9.—Knapsack sprayer. The handle can be removed and the tank carried in the hand instead of on the back, if desired.

The barrel pump, however, has nearly driven out the knapsack outfit in commercial operations. In spraying several acres of cantaloupes once the writer was surprised to find that a man with the knapsack outfit could do the work at exactly the same price as an outfit consisting of a barrel mounted on a sled drawn by one horse and operated by three men, one to do the pumping and drive the horse and two to carry the nozzles. The latter outfit, however, got over the ground so much more rapidly and saved so much time that it was mainly used. The objections to the knapsack pumps, however, are numerous. It is hard to get the required pressure in the pump on account of its small size and instability. It is rather heavy to carry on the back and is very liable to leak, and the operator who can handle one all day without getting his back wet and some of the liquid down his neck is fortunate. As a rule, the low pressure obtained by the knapsack pump results in an inferior job of spraying, though with a strictly first-class Vermorel nozzle this is not necessarily so.

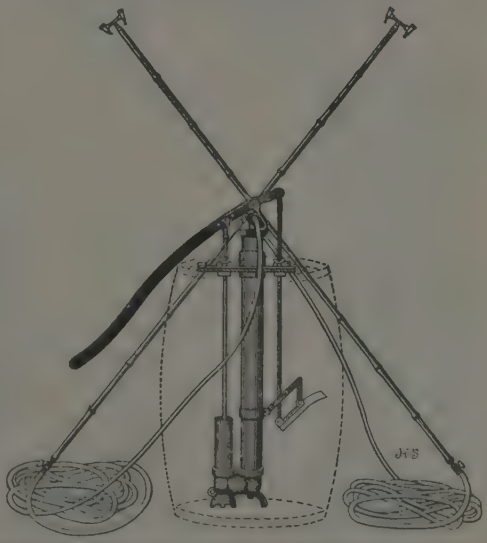

FIG. 10.—Barrel spray pump fitted with hose and bamboo extension rods for orchard spraying.

The barrel pump.—No type of spraying outfit is more widely used or has given better satisfaction in small or medium-sized commercial plantations than the barrel pump (fig. 10). A great many different forms are now supplied by the makers of spray pumps, and a number of them are efficient and successful. They are mounted in a great variety of ways. An ordinary 50-gallon whisky or kerosene barrel forms an excellent though inexpensive tank for holding the spray. The pump, according to its design, can be inserted in the end or the side of the barrel. The barrel may then be mounted to suit the operator on a sled or on two wheels, or it may be placed in a cart or wagon. A small sled can be made in a few minutes by spiking some plank across a couple of pieces 2 by 4 inches, or, better, 3 by 4 inches, with the ends rounded to serve as runners. Such an outfit can be drawn

through narrow rows of potatoes, vegetables, or other crops, where a wagon could not go. The ordinary 2-wheeled cart makes a very convenient rig to use with the barrel sprayer. One man can easily drive the cart and do the pumping, while one or two additional hands can apply the spray from the ground.

The tank outfit.—Various forms of tanks can be mounted on a two-horse wagon and thus enable a larger quantity of spray to be carried into the field. These tanks are sometimes square or rectangular.

FIG. 11.—Large hand spray pump with double vertical cylinders for use with tank outfits.

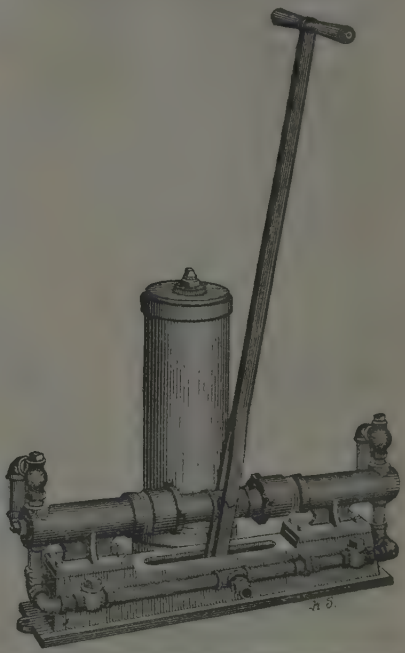

FIG. 12.—Large hand spray pump with double horizontal cylinder for use with tank outfits.

Some orchardists prefer to mount a large hogshead, either end up or on its side, and to pump the spray from that. As a rule, however, the best style is either a rectangular tank or a half-round tank, flat on top. With the rectangular or half-round tank an ordinary barrel pump can be used, but it is much better to use one of the larger tank pumps especially made for the purpose (figs. 11 and 12). These can be mounted either on top of the tank or on a platform at either end. The regular tank pump has a suction tube of whatever length is de-

sired, which draws the spraying mixture from the tank. One of the great advantages of the tank-pump outfit is the convenience of arranging an elevated platform. Where tall trees are to be sprayed it is almost impossible to reach the tops from the ground with extension rods of reasonable length. A scaffolding or tower of the height desired can be built on top of the wagon and the operator can thus be elevated 10 or 12 feet from the ground. Two types of the tank-pump outfit are shown in the accompanying illustrations (figs. 13 and 14).

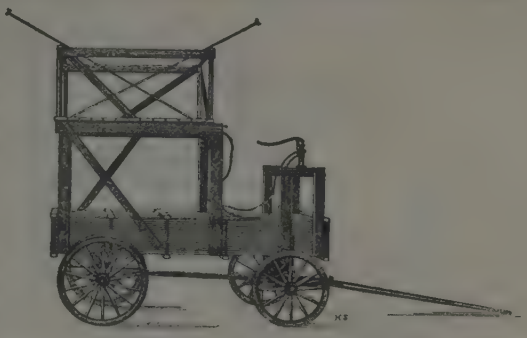

FIG. 13.—Tank outfit with hand pump for orchard use. The elevated platform permits the spraying of tall trees.

GEARED SPRAYERS.

In the above-described outfits the pressure on the pump is secured by man power. Ingenious fruit growers, as well as manufacturers, have devised several contrivances by which power is obtained by means of a sprocket wheel from the wheel of the wagon. There are a number of different devices, several of which are more or less successful. As a rule these geared devices are better adapted to low-growing crops, like potatoes and strawberries, and possibly also to vineyards, than they are to large orchard operations, although they have been used a good deal in orchards. In spraying fruit trees the operator frequently stops long enough to thoroughly coat each tree before proceeding. Usually this can not be done with the geared sprayers, although some have provision for storing up the pressure.

STEAM AND GASOLINE OUTFITS.

The highest type of spraying outfit consists of a steam, gasoline, or kerosene pump mounted on a wagon and drawing the liquid from a tank of from 100 to 300 gallons. Several growers use very successfully a small 2 or 3 horsepower steam boiler and a bronze steam pump. This is carried on a platform on the wagon (fig. 14). The only objection to such an outfit is its weight, but, on the other hand, those who have used steam sprayers seem to have less fault to find than the users of the gasoline sprayers.

Recently the writer has used a very successful kerosene outfit very similar to the one described above. With a gasoline or steam outfit

FIG. 14.—Gasoline power sprayer with 250-gallon tank and elevated platform.

it usually pays to have four leads of hose and four men spraying at a time.

HOSE AND EXTENSION RODS.

Nothing contributes more to success in spraying operations than satisfactory hose and nozzles. In ordinary spraying operations with the barrel pump, half-inch hose is commonly used. As a rule, however, three-eighths or one-fourth inch hose is better. The lighter hose is easier to handle and is less likely to kink and break. Good three-ply or four-ply hose in either case should be bought. It usually does not pay to try to use cheap hose in spraying. The couplings should be of a style readily adjusted in the field by means of a screw-driver, and everything must be kept tight to stand pressure, especially in case of the power outfits.

The ends of the hose should be attached to extension rods of suitable lengths for the work. (See figs. 10 and 13.) With the knapsack sprayer a short rod 16 or 18 inches long is sufficient. It should be light and of brass. For certain work it is desirable to have a 3-foot rod. With a barrel sprayer where the operator is free to handle the sprayer a 3-foot extension rod is the best for all plants that can be reached by it. This includes low-growing crops like potatoes, strawberries, grapevines, etc., and trees up to 8 or 10 feet high. For trees of more than this height brass extension rods up to 6 or 8 feet long give good results. Occasionally in getting up a very cheap outfit one-fourth inch iron gas pipe may be used. It is heavy and clumsy, however, and is only a temporary expedient at best. For all lengths above 6 feet a bamboo extension rod is recommended. This consists of a small brass tube supported by a bamboo rod. Two forms of stopcocks for extension rods are shown in figures 15 and 16.

FIG. 15.—Brass stopcock for ¼-inch pipe or bamboo extension.

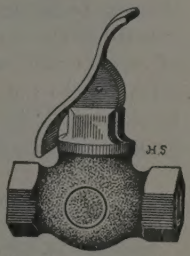

FIG. 16.—Automatic stopcock, opened or closed by spring pressure.

SPRAY NOZZLES.

The most important part of the whole apparatus is the nozzle. Unfortunately this feature has been much neglected by pump manufacturers, and many inferior nozzles have been sent out to farmers. There is a tendency to improvement in this direction, however. The actual results in the application of the spray mainly depend upon the efficiency of the nozzle. In general the best nozzle is the Vermorel, or a nozzle of that type (fig. 17). This consists of the "cyclone" nozzle, as invented by Barnard, in which the spray enters a cylindrical eddy chamber through a tangential opening at the side. It circles violently in the eddy chamber, and leaves the nozzle through a perforated cap and, still whirling, flies into a minute mist-like spray of the desired thinness. Vermorel added the plunger or degorger, which enables the operator to thrust the needle-shaped pin through the small opening to prevent clogging.

FIG. 17.—Vermorel spray nozzle.

With a good Vermorel nozzle, properly drilled on the inside, and having the correct style of eddy chamber, with a pressure of 40 pounds to the square inch, a fine and satisfactory spray will be produced. Such nozzles are very rarely found on the market in recent

years. Most of the nozzles require a pressure of 75 to 100 pounds to give a good spray. With this higher pressure almost any nozzle of this type gives good results. A good Vermorel nozzle is really an exact piece of work. The eddy chamber should be carefully drilled, and smooth on the inside, and the tangential inlet should also be correctly drilled and not simply cast in the brass. The cap itself is perhaps the most important. It should have its bearing on the outside, so as to avoid any interfering washers, and the vent should be exactly in the center, and true and smooth. The cap should be made of hard brass, and the size of the opening should vary from one-sixteenth to one twenty-fourth of an inch, according to the pressure to be used. The greater the pressure the larger the opening and the greater the quantity of spray that can be thrown.

HOW TO OBTAIN SUCCESS IN SPRAYING.

Success in spraying is to be secured only by careful attention to details in two principal directions: (1) Sprayings must be timely, and the proper time varies with the particular conditions. The operator should know what disease or diseases he is expecting to prevent by the application of the spray, and should thoroughly post himself beforehand as to the correct times and intervals for spraying for that particular disease. The spray must be applied ahead of the infection periods of the fungi. (2) The spraying should be thoroughly done. In dormant spraying a coarser spray can be used than in summer spraying, because the object is merely to form a complete coating of the spray over the wood. In summer spraying, however, an exceedingly fine, mist-like spray reaching every portion of the plant and covering with minute dots, preferably no larger than a flyspeck, every square inch of the fruit and foliage is necessary. It is not necessary that the minute specks of the spray should entirely coalesce into a coating, although where a second or third treatment is made this often results. But there should be no spaces the size of one's thumb nail not thoroughly peppered with the spray.

IDENTIFICATION OF PLANT DISEASES.

When the farmer or fruit grower is in doubt regarding the character or name of any plant disease with which he has to contend it is best to write to the agricultural experiment station of his State or to the United States Department of Agriculture, sending specimens for examination, as directed on the following pages. In most cases printed matter containing full accounts of the disease and its treatment can be furnished without cost.

LIST OF STATE EXPERIMENT STATIONS.

The list of agricultural experiment stations follows. Mail may be addressed to the director of the station or merely to the station, as for instance—Agricultural Experiment Station, Lincoln, Nebr.:

ALABAMA—
College Station: *Auburn.*
Canebrake Station: *Uniontown.*
Tuskegee Station: *Tuskegee.*
ALASKA—*Sitka.*
ARIZONA—*Tucson.*
ARKANSAS—*Fayetteville.*
CALIFORNIA—*Berkeley.*
COLORADO—*Fort Collins.*
CONNECTICUT—
State Station: *New Haven.*
Storrs Station: *Storrs.*
DELAWARE—*Newark.*
FLORIDA—*Lake City.*
GEORGIA—*Experiment.*
HAWAII—
Federal Station: *Honolulu.*
Sugar Planters' Station: *Honolulu.*
IDAHO—*Moscow.*
ILLINOIS—*Urbana.*
INDIANA—*Lafayette.*
IOWA—*Ames.*
KANSAS—*Manhattan.*
KENTUCKY—*Lexington.*
LOUISIANA—
State Station: *Baton Rouge.*
Sugar Station: *New Orleans.*
North La. Station: *Calhoun.*
MAINE—*Orono.*
MARYLAND—*College Park.*
MASSACHUSETTS—*Amherst.*
MICHIGAN—*Agricultural College.*
MINNESOTA—*St. Anthony Park, St. Paul.*
MISSISSIPPI—*Agricultural College.*
MISSOURI—
College Station: *Columbia.*
Fruit Station: *Mountain Grove.*
MONTANA—*Bozeman.*
NEBRASKA—*Lincoln.*
NEVADA—*Reno.*
NEW HAMPSHIRE—*Durham.*
NEW JERSEY—*New Brunswick.*
NEW MEXICO—*Mesilla Park.*
NEW YORK—
State Station: *Geneva.*
Cornell Station: *Ithaca.*
NORTH CAROLINA—*Raleigh.*
NORTH DAKOTA—*Agricultural College.*
OHIO—*Wooster.*
OKLAHOMA—*Stillwater.*
OREGON—*Corvallis.*
PENNSYLVANIA—*State College.*
PORTO RICO—*Mayaguez.*
RHODE ISLAND—*Kingston.*
SOUTH CAROLINA—*Clemson College.*
SOUTH DAKOTA—*Brookings.*
TENNESSEE—*Knoxville.*
TEXAS—*College Station.*
UTAH—*Logan.*
VERMONT—*Burlington.*
VIRGINIA—*Blacksburg.*
WASHINGTON—*Pullman.*
WEST VIRGINIA—*Morgantown.*
WISCONSIN—*Madison.*
WYOMING—*Laramie.*

HOW TO SEND SPECIMENS.

Correspondence.—Persons desiring to consult the Department of Agriculture or a State experiment station regarding any plant disease should write a letter stating the facts in the case, and if specimens are sent, giving notice of the same. This letter should not be inclosed in the package containing the specimens.

Postage rate.—Packages containing specimens of diseased plants sent by mail are rated as fourth-class matter and require postage at the rate of 1 cent an ounce (16 cents per pound). No written matter may be inclosed with the specimens except the labels and the name and address of the sender. The latter is often written on the outside of the wrapper.

Limitations.—No package may weigh over 4 pounds. Nothing should be sent that can in any way injure other mail matter. Liquids must be in tight bottles, packed

in approved mailing cases. Postmasters will give all necessary information on request.

Select material with care.—If the plants are small, send them entire, including roots. Loose dirt should be carefully shaken or washed off. Samples of the soil are not needed, and the dirt often injures the specimens in transit. Choose specimens representing various stages of the trouble. In the case of many leaf diseases, the later stages are most needed for identification, while with bacterial diseases, stem-blights, wilt, and diseases of fruits the earlier stages are usually most satisfactory. All stages should be sent. Fleshy or moist, watery material likely to become decayed or offensive while in transit should be packed as dry as possible. If the material is very perishable, dry completely or preserve in alcohol before sending.

Care in packing is important to make identification easier. If the specimens consist of leaves, straighten them out between layers of newspapers. If they are stems or solid parts, wrap each in dry newspaper. Fruits likely to be crushed should be sent in small strong boxes. *Do not pack moist.* As a rule, specimens carry best if sent while fresh, without moistening the wrappings, while an excess of moisture causes mold and decay. Never lay wet cotton against specimens, as it sticks to them. In sending several fruits, wrap each separately in tissue paper.

Label each specimen.—The name of the plant and the place and date of collection should be written on a slip of paper and inclosed with each specimen. When the name of the diseased plant is not known, as in the case of wild species, send flowers or fruits from healthy plants to aid in identification. If the specimens sent are mentioned in your correspondence, number them and refer to them by number.

Sending by express.—When material is sent by express the cost of sending should always be prepaid.

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